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POWDERY SCAB OF POTATOES.

W. F. Morse

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I am afraid that you may research publication, an our potato growers gener It was also published at than we do now. It is qu the conditions which obt evident now that under o to develop as a serious regions. Unfortunately, growing area. I may say unequalled as a potato p present year, however, h was almost impossible to experimental purposes fo three years time. I am i climatic conditions, and growers in the selection learned to avoid certain a greater degree.

HIGHMOOR FARM { VERNON FOLSOM, Laboratory Assistant
 WELLINGTON SINCLAIR, Superintendent
 HAROLD G. GULLIVER, B. A., Scientific Aid
ROYDEN L. HAMMOND, Seed analyst and Photographer
CHARLES S. INMAN, Assistant

BULLETIN 227.

POWDERY SCAB OF POTATOES.

W. J. MORSE.

Following the discovery of powdery scab in Maine and adjoining portions of Canada this Station has received many letters of inquiry as to the appearance and nature of the disease, means of dissemination, methods of control, etc. Since powdery scab is of so much importance from the standpoint of the potato industry and since the demand for information on the subject has been so great, it has become necessary to prepare for circulation within the State a brief résumé of the important facts known about the disease. Naturally much of the material here presented has been obtained from European sources, but as far as possible the description of the disease and the comparisons made with potato diseases which might be mistaken for it, etc., have been based upon observations made by the writer and others in the State of Maine.

HISTORY AND DISTRIBUTION OF THE DISEASE.

Some difference of opinion has existed as to how long powdery scab has been recognized as a specific disease. This is based on the question of the identity of the disease described by Brunchorst,* in Norway in 1886 as caused by a slime-mold with that described by Wallroth and others in the early forties as being produced by a fungus. Pethybridge in a recent publication† has, in the writer's opinion, shown quite conclusively

* Brunchorst, J. Ueber eine sehr verbreitete Krankheit der Kartoffelknollen. Bergens Museums Aarsberetning 1886, p. 219.

† Pethybridge, G. H. On the Nomenclature of the Organism Causing "Corky" or "Powdery-scab" in the Potato Tuber, *Spongospora subterranea* (Wallr.) Johnson. Jour. Royal Hort. Soc. 38 : 524-530. 1913.

that the figures and descriptions published by these earlier writers could refer to nothing else than what we know today as *Spongospora subterranea*.

The attention of scientific men was first called to the disease by means of a paper sent by Doctor Wallroth and presented at a meeting held in Brunswick, Germany, September 22, 1841. This paper, however, was not published until the following year.* It should be mentioned in passing that the disease was already sufficiently well known at that time so that the German farmers had applied a common name to it. A study of the literature reveals the fact that during the next 10 or 15 years powdery scab or the organism causing it was described or discussed in a dozen or more different publications. From 1856 on, and up to about six or eight years ago, only a very few important articles appeared which dealt with this disease although it was figured and described in various text-books and manuals in the meantime. One of these important contributions was that of Brunchorst already mentioned and another was a short article by de Lagerheim† in which he records the occurrence of the disease on potatoes purchased at a market in Quito, Ecuador. He called attention to the significance of this fact as South America is the home of the potato, and that the disease is generally known in Quito and manifests itself on potatoes from various localities. The natives there called it "Cara" which is equivalent to the English word scab.

During the past few years several very important papers have appeared dealing with the subject of the powdery scab and the organism which produces it. These have mostly come from pathologists in Great Britain and Ireland where the disease appears to be widespread and destructive and is receiving considerable attention. The first report of powdery scab in North America was made a little over a year ago by Prof. H. T. Güssow,‡ Dominion Botanist of Canada, who stated that the first specimens were received from the Province of Quebec where

* Amtlicher Bericht über die neunzehnte Versammlung deutscher Naturforscher und Aerzte zu Braunschweig in September 1841 : 1842.

† de Lagerheim, G. Remarks on the Fungus of a Potato Scab. Jour. of Mycology 7 : 103-104. 1892.

‡ Güssow, H. T. Powdery Scab of Potatoes *Spongospora subterranea* (Wallr.) Johns. Phytopathology 3 : 18-19. 1913.

the disease appeared to be well established in some counties. It is also recorded in isolated cases in widely separated regions of Canada, namely Cape Breton, Nova Scotia, New Brunswick, Ontario and Alberta. Certain observations made by Dr. I. E. Melhus of the Bureau of Plant Industry in the fall of 1913 showed that the disease is quite widely distributed in those portions of the Province of New Brunswick which adjoin Maine and especially common in the lower St. John Valley.

The first report of powdery scab in the United States was made by the writer on May 27, 1913, and based upon tubers received some months before from Massachusetts and Nebraska.* Almost at the same time Dr. I. E. Melhus reported the disease as being found at Presque Isle, Maine †.

Up to about February 1 of the present year it was supposed that the Presque Isle case, which had been traced to an importation of seed potatoes from Ireland two years ago, represented the only occurrence of the disease in the State of Maine. About this time potatoes which were being taken across the St. John River for shipment from one of the northern border towns of Maine were found by the Canadian inspectors to be affected by powdery scab, and so reported to Washington by the New Brunswick Commissioner of Agriculture. Acting upon this information Doctor Melhus, representing the Federal Horticultural Board, Mr. A. K. Gardner, State Horticulturist, and the writer at once began a preliminary inspection of this and adjoining territory. This was later supplemented by Mr. Gardner so as to include all the important potato growing sections of Aroostook and some of the adjoining portions of Penobscot and Washington Counties.

This preliminary inspection showed that the disease was more common in the northern part of the county, along the Canadian border. Apparently powdery scab has only recently been introduced into Maine and to date only a small percentage of the farms in the section where it has been found have become infested. Up to the present time it has not been reported in the central and southern parts of the State. Storage

* Morse, W. J. Powdery Scab of Potatoes in the United States. Science 38 : 61-62. 11 Jl 1913.

† Melhus, I. E. The Powdery Scab of Potato (*Spongospora solani*) in Maine. Science 38 : 132-133. 25 Jl 1913.

bins containing some 13,000 barrels of potatoes, grown in 5 or 6 different towns, were recently inspected by Mr. M. Shapovalov and the writer in Piscataquis County and no powdery scab was found. However, potato growers in other parts of the State should be constantly on the watch for the disease, especially if they have recently used seed from the districts now known to be infested. In this connection it may be said that there is probably less danger at present of obtaining powdery scab from these sections than in the immediate past as the system of inspection and certification established by the State Department of Agriculture in coöperation with the Federal Horticultural Board is designed to prevent the dissemination of the disease from these infected districts to other parts of this State or to other States.

CAUSE OF THE DISEASE.

The organism, *Spongospora subterranea* (Wallr.) Johnson, which is responsible for the production of powdery scab is quite different from the one which causes the ordinary type of scab with which Maine potato growers have been acquainted for many years. Powdery scab is produced by one of the slime molds which latter belong to the lowest order of living organisms, on the boundary line between the animal and vegetable kingdoms. It is the same type of organism as that which causes the well known club root of cabbage and allied plants. The facts we know regarding its life history may be briefly stated as follows: The earliest stage observed consists of a simple protoplasmic body of the ameba type located within the young potato cells. The nucleus of this ameba divides, and generally in the early stages of the infection this is followed by a division of the ameba itself, which process continues until a number occur in one cell. According to Osborn* who recently studied the matter quite carefully these amebæ apparently do not have the power to migrate from one cell of the potato to another, but as the potato cell divides a part of those contained in the original cell may go to each daughter cell resulting from this division. Thus the new cells become infected as soon as

* Osborn, T. G. B. *Spongospora subterranea* (Wallroth) Johnson. Annals of Botany 25 : 327-341 Ap 1911.

they are formed. These amebæ may continuously divide and increase in number as the cell in which they are located increases in size until they occupy the greater part of its area.

After the contents of the whole cell are exhausted the amebæ fuse together into a larger body called the plasmodium. This is the first stage of spore formation. Following this, certain other changes take place until finally the plasmodium is converted into a loose, spongy, yellowish or brownish body usually spherical to ovoid in shape and varying in size but averaging about 1-500 of an inch in diameter. These are the so-called "spore balls" of the organism. They are made up of aggregates of many small, spherical spores somewhat less than 1-5000 of an inch in diameter and it is the masses of these spore balls which constitute the powdery substance found in the pustules on the diseased potatoes.

EFFECT OF THE DISEASE UPON THE HOST.

The early stages of powdery scab on young tubers appear in the form of small pimples with a slight discoloration of the surface. When cut open the infected areas appear purplish.* These minute pustules may occur in patches or scattered over the surface of the tubers. As they enlarge they become raised and break through the epidermis which stands up and curls back around the spots in a characteristic manner.

If the surfaces of the diseased potatoes have not been exposed to too much friction, specimens may be collected frequently in the storehouses in the winter which show distinct, raised, blister-like, dark colored spots, usually not more than one-sixteenth to one-eighth inch in diameter, in no way resembling the common type of scab. These are shown indistinctly on the surface of the apparently decayed tuber illustrated in Figure 47. If the top of one of these blisters or pustules is carefully removed by means of a needle or pen-knife the interior will be found to be filled with dead tissue and a dark colored or brownish powder, frequently having a slight olive tinge. Usually, however, when affected tubers come under observation they have been subjected to more or less friction which has not only removed the top of the pustule but most of the powder as well, leaving rather flat and slightly raised spots. After one acquires a slight familiarity with the

* Osborn I. C. 328.

disease he can usually recognize it without trouble, even in this stage, on account of the size, grouping, and appearance of the spots. Unless several spots have run together and coalesced they are usually oval to circular in shape, small, seldom more than one-sixteenth to one-eighth inch in diameter and frequently several occur together in clumps. Occasionally they may extend diagonally across the surface of the potato in more or less irregular, parallel lines. The ragged, turned back margins of the ruptured epidermis already mentioned are usually still in evidence after the top of the pustules have been rubbed off.

The above description of the appearance of the disease upon the affected tubers applies to all the specimens which the writer has thus far seen which have been collected from the store-houses and cellars in Maine during the present winter. However, this is by no means the only form of alteration which the parasite may produce in the normal appearance of the host. In severe attacks, especially in moist soil, a distinctly warty appearance may develop, quite different from the ordinary type of powdery scab. These warts are several times larger than the scab pustules already described and are usually smooth and roundish, although somewhat irregular, varying in color from a light to dark brown in the case of the few specimens which the writer has seen, and more frequently occurring at the terminal or "Seed" end of the tuber. Figure 45 represents tubers produced in the plant pathology greenhouse at this Station, under rather moist conditions from a seed potato only slightly affected by the disease. According to Horne* "The warty condition is not so evident after the potatoes have been removed from the soil for some time. The warts become flattened and discolored, so that raised, more or less chocolate-colored scars remain in their stead." The same author states that this form of the disease is known in some parts of Great Britain as "Corky-end." Still another stage is recognized of which the writer has seen only one tuber which latter came from Canada. This is a condition where considerable portions of the surface of the tuber become destroyed and eroded, leaving a distinct, hollowed-out, cancerous area. This is illustrated in Figure 44. It is apparently a very advanced stage of the

* Horne, A. S. On Tumor and Canker in Potato. Jour. Royal Hort. Soc. 37 : 362-389. 1911.

disease which the writer has not had opportunity to trace from the beginning, and such European authorities as have been consulted do not state whether it results from either the warty stage just described, or from the running together of the individual spots of the scab or blister stage in severe attacks, or from both.

A few other characteristics of the disease as observed in Maine should be noted. The most important is, perhaps, that potatoes affected by powdery scab, especially in severe or moderately severe cases, show a tendency to wither rapidly. This takes place even under good storage conditions, and it becomes very evident if the tubers are removed from the cellar and kept at the temperature of the average living room for a few days. Very frequently the skin of the potato in a circle immediately surrounding the individual scab spots becomes depressed and browned, taking on a color very similar to that produced by the common dry rot associated with the late blight fungus. This similarity to the late blight dry rot is greatly increased if the spots of powdery scab are numerous and close together so that the discolored area of the skin becomes continuous. In such cases the tissues dry out and shrink away very rapidly beneath the discolored area, giving every appearance of a form of dry rot. Cutting through these blackened areas of the surface usually reveals simply a thin layer of dry, dead tissue resting on the apparently sound and healthy flesh of the tuber below. Frequently a distinct stratum of dry rot has been found beneath some of these discolored areas but whether or not this is due simply to secondary infection by some fungus I am not yet able to say.

DISEASES WHICH MAY BE MISTAKEN FOR POWDERY SCAB.

Common Scab. No doubt the chief reason that powdery scab was not recognized earlier by the potato growers in the sections where it is now known to occur is that they failed to distinguish the disease from the ordinary scab which has been common and widely distributed for many years. In comparing the two it may be said in the first place that the lesions produced by the common scab are on the average much larger. They are apt to be more irregular in size and shape and never appear as distinct warts or pustules containing a brownish powder.

They never produce a browning of the surrounding skin resembling decay, nor a pronounced shrinkage of the tubers, and never form large, deep, eroded pits or cankered areas in the tissues.

While portions of the epidermis may appear turned up, surrounding the spots of common scab, this characteristic is by no means so common or so apparent to the unaided eye as is the case with powdery scab. If the affected potatoes are wet and carefully washed to remove superfluous dirt another distinct characteristic can be observed. When wet, the spots produced by powdery scab are invariably darker colored than those of the common type. Common scab is, as a rule, nothing more than a surface ulcer, resulting from the irritation of the growth of the parasite in the superficial cells of the tissue. On account of the character of the lesions thus produced the keeping qualities of the tubers are practically uninjured and the value for food purposes is not materially lessened. It simply makes them unsightly and less easy to prepare for the table.

Silver Scurf. This disease, which is caused by *Spondylocladium atrovirens* Harz., has been given the name of "scab" and "dry scab" by some writers. Melhus* who has very recently described the nature and distribution of this disease in the United States maintains that we are not justified in applying the name scab to it as we already have two or three other different types of scab. Moreover as the disease ordinarily occurs on potatoes it is not a typical scab. Silver scurf is quite easily detected on light skinned varieties like Irish Cobbler and Green Mountain if the tubers are washed. According to the writer's observations the early stages of it appear as small, faint, roundish, or irregular discolorations on the skin of the tuber, and which may be easily overlooked if the latter is somewhat dirty. These discolored spots are usually from one-eighth to one-fourth inch in diameter. Later these may enlarge, run together, and cover considerable of the surface area of the potato. If conditions are moist the spots take on an olive color due to the fruiting of the fungus. In advanced stages the discolored areas change so that they present a silvery or glistening appear-

* Melhus, I. E. Silver Scurf, A Disease of the Potato. Cir. U. S. D. A. Bu. Pl. Ind. 127 : 15-24. 1913.

ance when washed. A little later the whole tuber may become shrunken and shriveled, but this condition the writer has not seen under the cool storage conditions of this State. In later stages also, fine black dots may appear on the surface of the tuber representing sclerotia of the fungus. These are quite readily made out by means of a hand lens.

While the above description applies very well to the most common type of the disease, the writer recently collected several tubers showing spots undoubtedly caused by *Spondylocladium* which, when compared with powdery scab and common scab, proved to be confusing to several individuals who were quite familiar with both of these diseases. The affected spots usually varied from one-eighth to one-fourth inch in diameter, they were approximately circular in outline, and usually either level with the surface of the tuber or slightly depressed. On the same tuber all stages could be found from the small discolored areas on the skin which are typical of the earlier stages of silver scurf to the spots described as resembling scab. These scab-like spots were brownish in color, the central portion being frequently, although not invariably, darker than the periphery. The spots are also frequently surrounded by a somewhat lighter brown ring. This seems to be made up of densely interwoven, light brown threads of the fungus. These latter also are usually found entirely covering the whole spot. If the spots are large and somewhat irregular they may, on superficial examination, be classed as common scab. If they are small, unless one has given the matter considerable attention he is apt to call them spots of powdery scab the surfaces of which have been removed by friction in rubbing against other potatoes. Figure 49 represents a potato affected by this type of the disease.

Rhizoctonia Scab.—The fungus *Hypochnus solani* P. & B. commonly known as Rhizoctonia from its non-fruiting stage has been attributed in some instances as the cause of a type of scab. In inspecting potatoes for powdery scab tubers showing lesions apparently produced by this fungus are sometimes found. These spots, particularly in advanced stages, are more of a pit than a scab and should not be confused with powdery scab, although potatoes have been sent to this Station on the supposition that they represented this last type of disease.

The beginning of these pits is usually indicated by a slight circular browning on the surface of the potato in the region of a lenticel. As the diseased area increases it becomes slightly depressed and brown in color. Usually the margin is somewhat more sunken forming a sharp boundary line between the healthy and diseased tissues. Occasionally diseased areas like this will reach the size of from one-eighth to one-fourth of an inch without any other superficial changes. More frequently the tissues surrounding the lenticel soon begin to shrink away leaving an opening in the center of the diseased area. This may widen out into a broad, shallow pit, or if the disease penetrates any depth into the flesh it may develop into a canal following the center of this area. Figure 52 represents a potato affected in this manner.

Rhizoctonia is very common in New England potato soils and the sclerotia of the fungus are frequently seen on the surfaces of potato tubers. These are small black, or dark brown, often irregular shaped bodies, commonly flattened and closely attached to the skin of the tuber. They can usually be removed with more or less difficulty by means of a stiff brush or by pressure with the thumb nail, leaving the skin of the tuber beneath, entirely sound and uninjured. These sclerotia are in reality very compact masses of densely woven threads of the fungus and serve as a resting stage to carry it over winter, but the housewife usually considers them to be closely adhering particles of dark colored soil. If the sclerotia are rounded, fairly regular in shape, of proper size, and appear on potatoes more or less covered with dirt they may be taken for pustules of powdery scab. Their true nature is readily shown if the tubers are washed or the dark spots are scraped off with a knife or by means of the thumb nail. Fig. 51 illustrates a potato covered by sclerotia of Rhizoctonia, and photographed after being washed.

Wart disease. This disease which is caused by *Chrysophyctis endobiotica* Schilb., and is also known as potato canker and potato tumor is not known to occur on the mainland of North America. When both diseases occur together in England it is said that the warty stage of powdery scab may sometimes be mistaken for the true wart disease, but it is stated that if

whole plants are dug up and examined the differences can usually be detected. Spongospora warts are usually smooth and rounded, while those produced by Chrysophlyctis are generally irregular and broken, soon taking on a coral-like structure and always begin around the eyes of the tuber.

ECONOMIC IMPORTANCE OF POWDERY SCAB.

While experience in this State is yet too limited to be made the basis of any definite conclusions the opinions expressed by those who have studied the disease most carefully in Great Britain and Ireland seem to warrant the conclusion that powdery scab is without doubt the most serious disease with which the Maine potato growers have ever had to contend. It has already been pointed out that observations made in this State indicate that potatoes badly affected by the ordinary type of powdery scab wither very rapidly and frequently show a discoloration of the surface resembling a dry rot. Also in case of severe infection large warty outgrowths or cancerous areas may be produced.

One of the most specific statements recently made regarding the economic importance of the disease appeared in an article by Güssow* in which he says: "The disease should by no means be regarded lightly. Severe attacks occur when potatoes are planted year after year on infected land. Where this is practiced the result will be potatoes hardly superior in quality to those affected by canker (wart disease). This fact is worthy of notice, especially since, as in the case of canker, no preventive measures have proved of much value." Pethybridge in 1912 called attention to the fact that the organism causing powdery scab not only may attack the tuber, but is also capable of producing galls on the roots as well as on the underground tuber bearing stems of the potato, and the spore-balls produced on these root-galls are for the most part liberated in the soil. Perhaps the most important fact from the economic standpoint is that the disease in addition to being carried by the seed tubers may persist in infected soil for some time, thus making it worthless for potato culture. Pethybridge has also stated

* I. c. 19.

that manure of a pig fed with potatoes affected with powdery scab carried the germs of the disease. Certain other writers have pointed out the fact that contaminated manure may be a means of spreading the infection.

It is claimed that healthy potatoes which have been in contact with diseased ones may carry powdery scab. This naturally leads to the supposition that it may be spread by mean of sacks or other containers or by means of tools such as planters, etc. Another possibility is that plows, harrows or other tools used for working infected land may carry with them the germs of the disease to contaminate portions of the farm now free from powdery scab. Little data are to be had on this phase of the subject and until we know more about the matter the possibility of spreading the disease in this way should be kept in mind and guarded against as far as possible.

PREVENTIVE MEASURES TO BE EMPLOYED AGAINST THE DISEASE.

For the length of time powdery scab has been known it is surprising how little has been done toward solving the problem of its control and eradication as indicated by published work. So far as the writer has been able to learn Doctor Pethybridge of Ireland is about the only investigator who has conducted experiments along the line of soil and seed treatment.

Speaking of work done in 1909 Dr. Pethybridge says,* "Experiments on treating affected seed potatoes with disinfectants showed that such seed, if planted subsequently on clean land, gave a clean crop after steeping for two or three hours in a solution of formalin (formaldehyde) at the rate of half a pint of 40 per cent formalin in fifteen gallons of water—"

The following year he gives the details of several new experiments †. Seed only slightly affected gave over 54 per cent of the crop scabbed, and 67 per cent of the crop was diseased where badly affected seed was used. Soaking in formaldehyde one part to 600 for 3 hours reduced the amount of scab to 2.6 per cent, showing a high degree of efficiency. Wetting the surface of the tubers and rolling them in flowers of sulphur eliminated all of the scab except about one per cent. A one

* Jour. Dep. Agr. and Tech. Inst. Ireland 10 : 254-256. 1910.

† Jour. Dep. Agr. and Tech. Inst. Ireland 11 : 26-29. 1911.

per cent solution of copper sulphate and soaking the potatoes for 3 hours gave even better results but the copper sulphate produced injuries sufficient to materially reduce the yield. Burgundy mixture (copper sulphate and sal soda) was nearly as efficient as formaldehyde but its effect on the crop was similar to the copper sulphate solution alone. Rolling moistened seed tubers in calcium cyanamide destroyed their germinating qualities. The same treatment with superphosphate destroyed four-fifths of the seed tubers but gave a clean crop.

These results coming from a recognized authority on potato diseases are very suggestive as to what may be done along the line of seed disinfection but the fact should not be lost sight of that a perfect score was only obtained at the expense of a largely reduced crop. Also it is doubtful if Dr. Pethybridge himself would care to predict how effective these methods of seed treatment would prove to be under Maine conditions. His results, however, do indicate promising lines of attack upon which to base experimental work in this State. No treatment of this nature should be absolutely relied upon till it has been tried out by a number of investigators, under a variety of conditions.

It will be noted that in his second series of experiments Dr. Pethybridge used a much weaker solution of formaldehyde (1 to 600) than is customary to recommend in this country for treating seed potatoes, but soaked for a longer time, 3 hours. This Station has always used and recommended one pint of 40 per cent formaldehyde in 30 gallons of water (1 to 240) and soaking the potatoes for 2 hours in this. This strength of solution has been found to be very effective in treating for the ordinary type of scab and for blackleg. Doubtless it would be more efficient than the weaker solution for a longer period.

Reasoning apparently on *a priori* grounds, since liming soils tends to control club root of the cabbage, also caused by a slime mold or myxomycete, led one English writer to recommend this for powdery scab. Pethybridge* has since shown that not only is lime not a soil disinfectant with reference to powdery scab but as is the case with common scab its application to the land

* Pethybridge, G. H. Jour. Dep. Agr. Tech. Inst. Ireland. 10 : 254-256. 1910, 11 c. 26-29. 1911, 12 : 19-22. 1912, 13 : 459-461. 1913.

actually increases the virulence of the disease. In the same series of articles this writer has given results which indicate that sulphur is of considerable value for soil treatment.

There is every reason to believe that the presence of powdery scab in Maine has been detected in time so that it will be possible to prevent its farther spread and possibly to eventually entirely eradicate it. However this can only be done through the coöperation and concerted action of all parties interested. In the section where the disease occurs no land should be replanted to potatoes in 1914 unless it is shown beyond doubt that the 1913 crop was free from powdery scab. For the coming year no seed stock should be used unless it is known to be free from contamination. Land known to be infected should not be used for potatoes again till more data has been accumulated with regard to the length of life of the organism within the soil.

No potatoes should be planted without first disinfecting them with formaldehyde or corrosive sublimate, for if by chance the healthy seed has become contaminated this would tend to eliminate the danger from this source. In fact there are many arguments in favor of planting no potatoes whatsoever without first disinfecting them. By careful selection of only sound, thoroughly healthy seed tubers, and then disinfecting it is possible to entirely eliminate blackleg, prevent the spread of ordinary scab, and also to overcome some of the losses from seed decay and so-called imperfect germination. There is no doubt that if careful selection of seed, along with disinfection had been generally adopted by our potato growers, and rigidly carried out in the past powdery scab, blackleg, etc., would not have gained a foothold in the State.

After the sound, healthy seed tubers have been disinfected great care should be taken not to contaminate them by allowing them to come in contact with, sacks, barrels or planters, etc., which may carry the germs of the disease.

DISINFECTION OF SEED POTATOES, IMPLEMENTS AND STORAGE HOUSES.

Many inquiries have been addressed to this Station asking for information as to the best method of disinfecting seed potatoes, implements and storage houses for powdery scab. As already stated only a comparatively small amount of atten-

tion has been given to this subject and some phases of it have not been touched at all. However there is available a large amount of data regarding the effects of certain disinfectants like formaldehyde and corrosive sublimate used for treating seed tubers for common scab, blackleg, Rhizoctonia, etc. The conclusions derived from this, taken in connection with the work of Pethybridge on powdery scab in Ireland, may serve as a tentative basis for recommendations as to disinfection, in the absence of any experimental results obtained in this country.

Formaldehyde, sometimes called formalin, as ordinarily used is perfectly safe to handle. A large number of trials by different investigators have shown it to be fully equal to corrosive sublimate for treating potatoes for common scab. The writer has also found it to be efficient in the case of the blackleg disease. Corrosive sublimate is a very active poison and should be handled with great care. It cannot be used in iron vessels and tubers treated with corrosive sublimate should not be fed to stock or left where animals can get at them.

According to the recent work of Gloyer* corrosive sublimate is much more efficient than formaldehyde in the treatment of seed potatoes for Rhizoctonia in that it thoroughly penetrates and kills the sclerotia of the fungus, while the latter does not. Hence where both Rhizoctonia and scab of either type are present corrosive sublimate is to be preferred. It is also possible that the greater penetrating power of corrosive sublimate claimed by Gloyer may make it more efficient for treating for powdery scab. However until accurate experimental work demonstrates the superiority of one over the other when used against powdery scab it is impossible to say which is the most effective with reference to this disease. The amounts of the disinfectants to use and the length of time for treating seed potatoes are as follows:

FORMALDEHYDE.

| | |
|---------------------------------------|------------|
| Formaldehyde, 40 per cent..... | 1 pint |
| Water | 30 gallons |
| Soak tubers 2 hours in this solution. | |

* Gloyer, W. O. The Efficiency of Formaldehyde in the Treatment of Seed Potatoes for Rhizoctonia. Bul. N. Y. Agr. Exp. Sta. 370. 1913.

CORROSIVE SUBLIMATE.

| | |
|---|------------|
| Corrosive sublimate | 4 ounces |
| Water | 30 gallons |
| Soak tubers 1 1-2 hours in this solution. | |

Planters and other tools which have in any way come in contact with the germs of powdery scab should be washed clean with water and then thoroughly washed or sprayed with a strong solution of formaldehyde and allowed to stand a few days before using. Barrels or other containers may be handled in the same way. Sacks can be disinfected by soaking in formaldehyde but the same results could doubtless be obtained at less expense by steam sterilization at some central station. Sacks should be purchased only under a guarantee that they are free from contamination with powdery scab.

Special attention should be given to storage houses. All loose dirt and rubbish, including decayed potatoes or other cult., should be removed from the interior and from around the outside of the house. As much of this material as possible should be burned. What remains unburned should be thoroughly soaked with a strong solution of copper sulphate. After all rubbish has been removed from the potato house the interior walls and floors should be thoroughly sprayed with a solution of copper sulphate 5 pounds to 50 gallons of water.

More complete disinfection of empty houses may be secured by the use of formaldehyde gas following spraying with copper sulphate. To accomplish this make all outside doors and windows as tight as possible. For every 1000 cubic feet of contents use 23 ounces of potassium permanganate and 3 pints of formaldehyde. Spread the permanganate evenly over the bottom of one or more large vessels like a wash tub or half of a kerosene barrel, these latter arranged in the central parts of the house or rooms. Pour the formaldehyde quickly over the permanganate, being sure that it is well mixed with the latter. Leave and tightly close the house at once. Allow to remain closed 24 hours or longer. Barrels and tools, if clean, can be disinfected at the same time, although probably not so thoroughly and efficiently as by washing with formaldehyde solution.

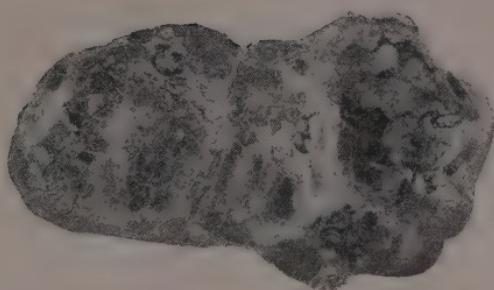


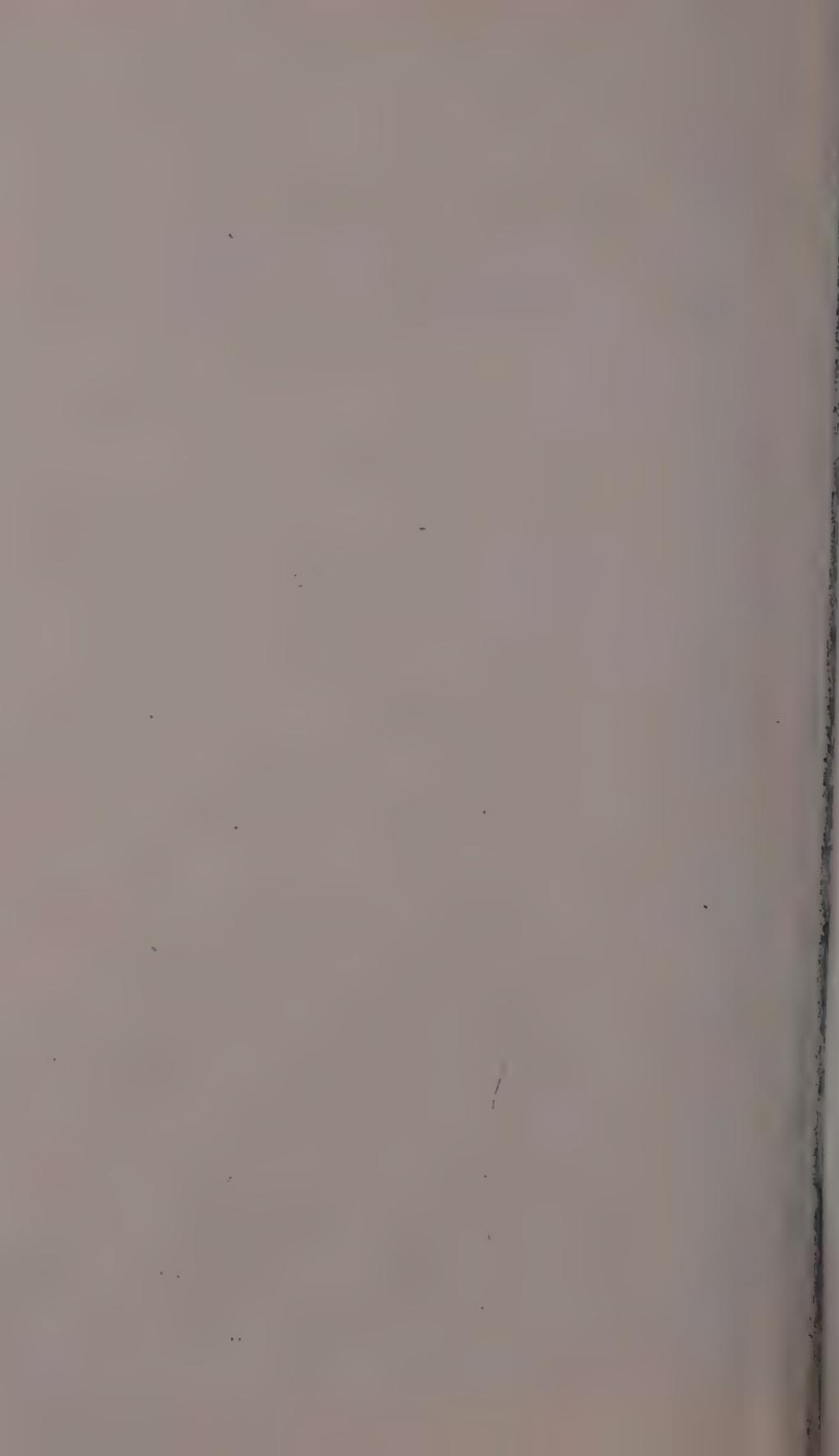
FIG. 44. Powdery scab, canker stage.



FIG. 45. Powdery scab, warty stage.



FIG. 46. Powdery scab, ordinary stage after having the tops of the pustules removed by rubbing against other tubers—the usual appearance when collected from storage bins in winter.



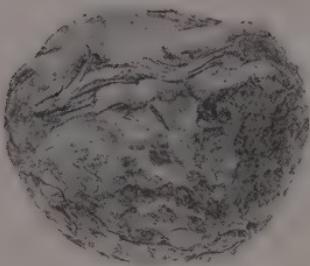


FIG. 47. Powdery scab showing apparent decay following a severe attack. The pustules are still in their original condition and in no way resemble scab spots.

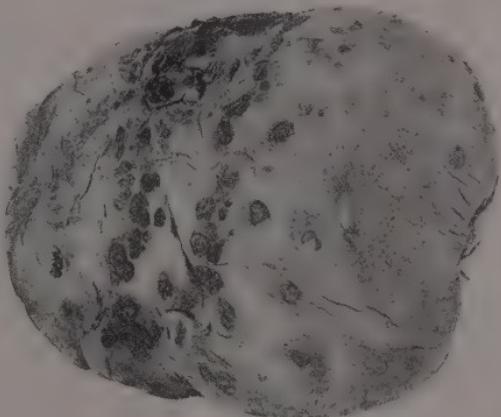


FIG. 48. A badly withered tuber—a common occurrence with tubers affected by powdery scab, after remaining some time in storage. The tops of nearly all of the pustules have disappeared, leaving scab-like spots.

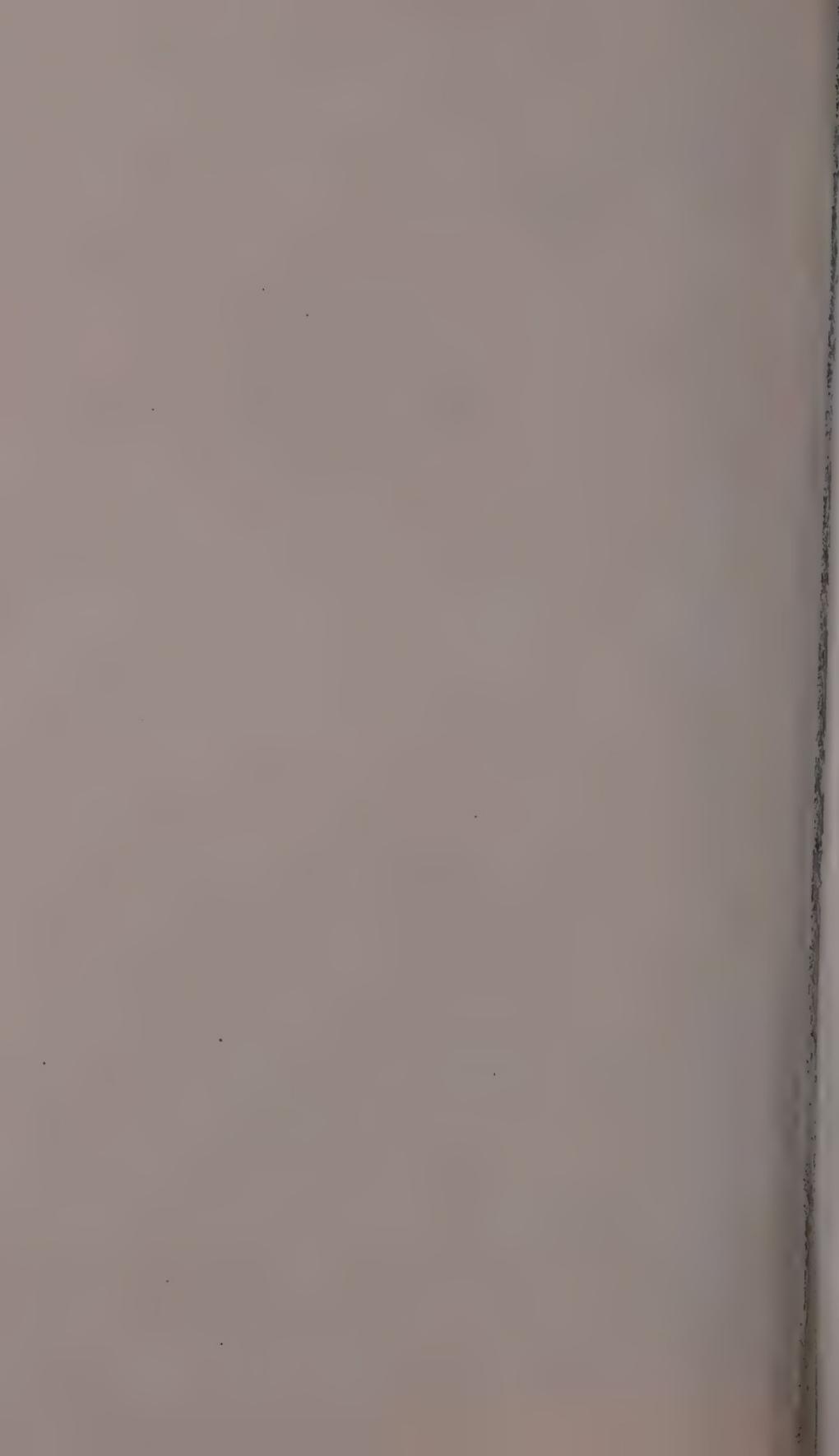




FIG. 49. Scab-like spots caused by *Spondylocladium atrovirens* Harz.
Not common.

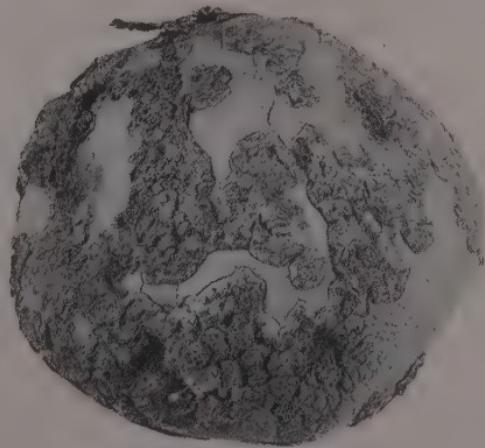


FIG. 50. Common scab, caused by *Oospora scabies* Thaxter.

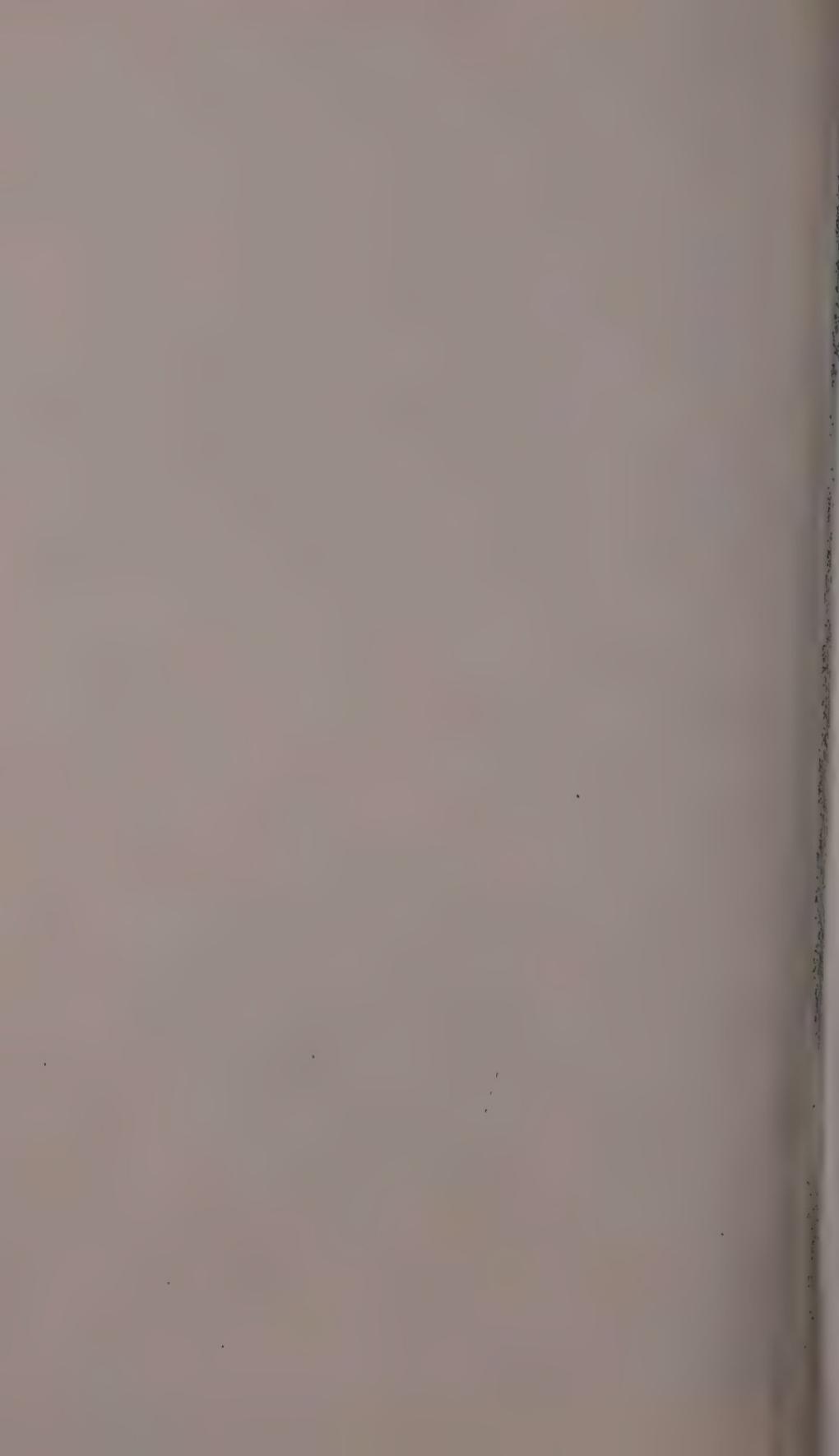




FIG. 51. Sclerotia of Rhizoctonia (*Hypochnus solani* P. & D.)



FIG. 52. Scab-like spots produced by Rhizoctonia.

